



## SUPPLY CHAIN AND INNOVATION ACTIVITY IN TRANSPORT RELATED ENTERPRISES IN EASTERN POLAND

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**ABSTRACT. Background:** One of the development strategies uses R&D activity as the main source of innovation, which is often carried out in cooperation with other units, but in particular in the supply chain, and therefore applies to cooperation between enterprises and their customers and suppliers.

The aim of the study was to identify the variable determinants of the impact of the character of relationships among enterprises and their suppliers and customers on their innovative performance, within regional industrial systems and to define the constraints for a model regional structure of innovation network tailored to the needs of Poland and its regions.

**Methods:** 167 enterprises belonging to the transport sector and operating in the area of Eastern Poland took part. In order to determine the impact of relationships with suppliers and customers on innovation activity, models based on probability analysis - probit models - were used.

**Results:** It can be clearly stated that the cooperation of industrial enterprises in the transport sector with customers and suppliers activates innovation activity and its specified attributes. However, the probability varies depending on the test variable adopted.

**Conclusions:** The cooperation with suppliers and customers is the cognitive aspect in the development of innovation activity in industrial enterprises representing the transport-related sector. Such cooperation has a stimulating effect on expenditures on innovation activity and on the implementation of innovative solutions in the field of technological innovation (products and processes).

**Key words:** logistics, innovation, supply chain, industry, transport, region.

### INTRODUCTION

The Eastern Poland macroregion is a compact area with the lowest level of economic development in Poland and one of the weakest in the European Union. The nature of the problems adversely affects the socio-economic situation and development prospects of the area largely in the structural dimension, which is a result of historical circumstances. There are also amplified negative effects of its peripheral location of this macroregion on the

external border of the European Union, similar to other areas still lagging behind.

The Eastern Poland region has a much lower level of development in comparison with both the average level for all other provinces in the country and the Poland's western provinces [Fiedorowicz, Duda 2007]. The level of development of the Eastern Poland provinces is 37% of the average level of EU development [Fiedorowicz, Duda 2008].

The development strategy for Eastern Poland identifying the key development

challenges facing the macroregion and how they are addressed should form part of the most important national and European determinants of development, so that it can serve as a basis for planning effective action of an operational nature.

One of these challenges is to increase the innovativeness of the region, which will contribute to the elimination of its technological backwardness in relation to other regions of the country and across the EU. This specific macroregion is in this regard subject to special, dedicated supra-regional support in the form of a number of operational and strategic programs of regional development.

Considering the above facts, the authors decided to find out which determinants stimulate innovation activity in Eastern Poland in terms of cooperation between transport-related industrial enterprises and their suppliers and customers. In general, the major objective of the research was to attempt to find the variable determinants of how the character of relationships between enterprises and their suppliers and customers impacts on their innovative performance within regional industrial systems and hence to define the constraints for a model regional structure of innovation network tailored to the needs of Poland and its regions. The results presented in this study represent only one finding. From the viewpoint of sampling, the authors decided to analyze the case of one region with low-weak industrial development. Such a solution allowed a more in-depth analysis of the features characteristic of regional industrial systems in the transport-related sector in Eastern Poland. The main hypothesis of this research is that innovative activity of economic entities is influenced by a number of determinants, and cooperation with suppliers and customers have the impact on innovation activity in a multidirectional way.

In the survey on the impact of relationships with suppliers and customers on innovation activity in industrial enterprises in the transport sector in Eastern Poland, 167 enterprises belonging to this sector and operating in the area took part. These included the following regions: Warmia-Mazury, Podlasie, Lublin, Świętokrzyskie and Podkarpackie

voivodeships. The transport-related industrial enterprises analysed come from the following represents sectors: locomotive, rolling stock and tram production, the production of motorcycles and bicycles, and transport equipment not elsewhere classified, manufacture of motor vehicles, trailers and semi-trailers, manufacture and repair of ships and boats.

Similar studies on factors determining of the regional development of areas which are less technologically advanced were conducted in similar regions such as Italy - Province of Messina (Sicily) [Ioppolo et al. 2016, Ioppolo et al. 2012]. Therefore, the decision was taken to analyze the determinants of innovative activity in the region.

## **SUPPLY CHAIN IN NETWORKS OF INNOVATION- THEORETICAL APPROACH**

One of the significant elements influencing how of a company functions properly is a well-organized logistics network. It should ensure the smooth operation of the distribution system, thanks to the best possible coordination of the movement of products in specific places to the criterion of time. The logistics network infrastructure considers the flow of materials, semi-finished and finished products, consisting of point objects and the roads connecting them by any mode of transport. Point objects include storage areas, manufacturing, distribution centers, and retail space. Setting up a logistics network is currently a necessary action in logistics companies. It should take into account above all markets, the cost of transportation of raw materials and finished products and storage costs. It should be noted here that the complexity of decision-making problems increases with product differentiation and a wide product range and geographical coverage, and also the number of customer segments. Diverse segments require the inclusion of additional nodes in the logistics system. The system consists of multiple cooperating nodes and creates a network [Kramarz 2009].

Nowadays, in relation to the ongoing process of internationalisation and globalisation, the majority of industrial enterprises, and mainly those involved in production, are elements of a more or less formalised networks of innovation [Świadek, Szopik-Depczyńska 2015]. In such relations vertical industrial cooperation prevails, that is cooperation with the suppliers and customers [Hakansson 1987] (this is confirmed in other studies by the authors). Such relations are not typically of a market nature. However, they are more durable and, so to speak, interactive (network type). Such relations are more stable, because they are based on common trust and allow implementation of the learning process [Asheim 1996]. Moreover, for this reason it is believed that this network activity (intra- and interregional), is currently the main success factor in the of innovation activity [Saxenian 1994]. The way the network of innovations functions on the local level may lead to the creation of opportunities for less developed regions. They allow small and medium-sized businesses to access global resources (including the resources of knowledge and technology), while on the other hand, they provide the possibility to produce products and offer them on the international market [Huggins 1995].

The supply chain strategy is shaped by supply and demand and as well as competition present in a given sector. However, the relationships between suppliers and consumers are also of some significance. In particular, one must take into account the use of control measures and power by the supply chain leader. Reflections on participants' behavior are part of the analysis of supply chain strategies described in pertinent literature and are treated as one of the determinants of their formation [Konecka, Matulewski 2014].

Business practice, in turn, is usually much more complicated. Companies - suppliers of products to customers - have their own suppliers and subsuppliers, and often also have intermediaries in the field of distribution. This means that they participate in supply chains, i.e. they are not independent creators of quality in the end-customer service. The reason is that there are also other supply chain participants which take part in this service. A production

company sometimes provides services only to intermediaries in distribution channels. Hence, the quality of customer service is affected by the whole supply chain, i.e. the manner of logistics cooperation among all of its participants, including suppliers of logistics services. If this cooperation is to be successful for the end customer, it may not be reduced to operative activities of transferring specific goods, but must be of a strategic nature [Długosz 2010].

## **COOPERATION WITH SUPPLIERS AND CUSTOMERS IN TERMS OF INNOVATION ACTIVITY**

Collaboration with suppliers offers only limited new knowledge, because these often operate in the same market as the firm. Information from the supplier and buyer might therefore be the same, or at least similar. Nevertheless, the supplier's knowledge is something very important for the firm, and as the supplier has another set of skills, this might be a resource for the firm to use. Furthermore, even if suppliers' knowledge is limited, it is easier to access this knowledge than that of other actors in the supply chain. The supplier also supports innovations more than other actors, due to the combination of common goals and complementary capabilities between the supplier and the firm [Un et al. 2010]. Wynstra et al. [2001] state that integrating suppliers leads to lower risk, as the risk is shared between the two firms (supplier and buyer), the firm can move faster into new markets, and also gain new resources. Hagedoorn [1993] states that if the information and knowledge are shared to a greater extent between firms, the quality of the product will be higher than if the information and knowledge exchange were to be poor [Hagedoorn 1993]. Lau et al. [2010] conclude in their research that suppliers might not want to reveal their knowledge and resources and thus not be willing to share all valuable information. By only delivering the required information, the innovation process might be disturbed, which will probably lead to less innovative products and lower performance [Lau et al. 2010].

When it comes to relations with customers, the information and knowledge they offer is extremely valuable for a firm's ability to innovate. Customer innovation is an important source of innovation for firms [Johansson, Möllefors 2013]. A study by Cohen et al. [2002] showed that 90% of the firms surveyed had used knowledge from the customers as an initiator for new innovation projects. To collaborate with customers in the innovation process, needs information must be converted to explicit information, which is very difficult [Nonaka 1994]. Another problem of using the information and knowledge from customers is that they do not have the same incentives and mindset as the employees in the firm. This makes it even harder to transfer useful and valuable information and knowledge from the customer to the firm [Szulański 1996]. Moreover, the average customer can only help the firm to innovate existing products and do so incrementally, because (s)he does not have the ability to identify the latent needs of the market and how it may be served [Füller, Matzler 2007].

In general, awareness of benefits that may be obtained by improving supply chain and logistics management is still in the initial phase in Poland, and this is on too low a level. What is needed is courage to trust your partners; strength, to break the stereotypes and fears in your own company; and charisma to make others follow you. That is why it is worth taking up the challenge. Those who succeed will be one step ahead of the competition [Stajniak 2010].

## **METHODOLOGICAL CONDITIONS OF THE CONDUCTED RESEARCH**

The methodological part of the analyses is based on probability calculus. When a dependent variable takes dichotomous values, the possibilities of using popular multiple regression, widely used for quantitative phenomena, are limited. The problem can be solved by an alternative solution - logistic regression [Frenkel 2000]. Its advantage is that analysis and interpretation of results are similar to the classical regression method, hence the methods for selecting variables and testing the hypotheses have

a similar pattern. There are, however, also differences, which include more complex and time-consuming calculations and producing residual plots which usually do not contribute significantly to the model [Stanisz 2007].

Generally, logistic regression is a mathematical model which can be employed to explain the impact of several variables  $X_1, X_2, \dots, X_k$  on a dichotomous variable  $Y$ . If all the independent variables are qualitative, the logistic regression model is equivalent to a log-linear model. To describe such a phenomenon, one could also employ probit regression [Świadek 2011].

Discrepancies between the probit and logit models focus on the specifications in the equation of random factor distribution. The logit model exists when  $F$  is the distribution function of logistic distribution, and the probit model is obtained when random factors have normal distribution [Maddala 2006]. The correlation between the Logit and Probit values is illustrated by the following equation:

$$\frac{\text{Logit}}{\text{Probit}} = \frac{\pi}{\sqrt{3}} = 1,8$$

With the methods of a dichotomous variable, the assessment of parameters is carried out using the method of the maximum likelihood (MNW). This method requires finding the vector of variables to guarantee the highest probability of the occurrence of values observed in the sample. This method applied in the case of small communities is often more advantageous in comparison with the competing estimators [Welfe 1988].

On the side of dependent variables attributes of innovation were highlighted in accordance with the international standards set by the OECD countries and Eurostat. These variables included [Oslo Manual 2008]:

- expenditures on innovation activity in relation to their structure,
- implementation of new products and technological processes.

Considering the fact that the variables are binary (i.e. they take two values - 0 or 1), the majority of the results will be presented at the level of the structural form of the model.

A "plus" sign preceding a parameter denotes that the probability of an innovative phenomenon in the selected group of entities is higher than for the rest of the population. Probit modelling is an efficient research tool in the case of big yet static samples where the dependent variable is qualitative. Each questionnaire was entered into an Excel spreadsheet for initial processing based on formal logic. The actual calculations were made with Statistica software.

## RELATIONSHIPS WITH SUPPLIERS AND CUSTOMERS IN THE SUPPLY CHAIN - RESEARCH RESULTS

The research about the determinants of innovation activity in Eastern Poland was

conducted with 1067 industrial enterprises. 167 of them were transport-related enterprises: manufacturers of motor vehicles, trailers and semi-trailers, manufacturers and repair industry of ships and boats and manufacturers of locomotives and rolling stock and tram, the production of motorcycles and bicycles and transport equipment not elsewhere classified.

In the group of 167 industrial enterprises in Eastern Poland, 112 of them cooperated with customers on innovative projects (products or/and processes). The graph illustrating the distribution of answers in terms of the main customer for industrial enterprises which are cooperating in innovative projects is shown below.

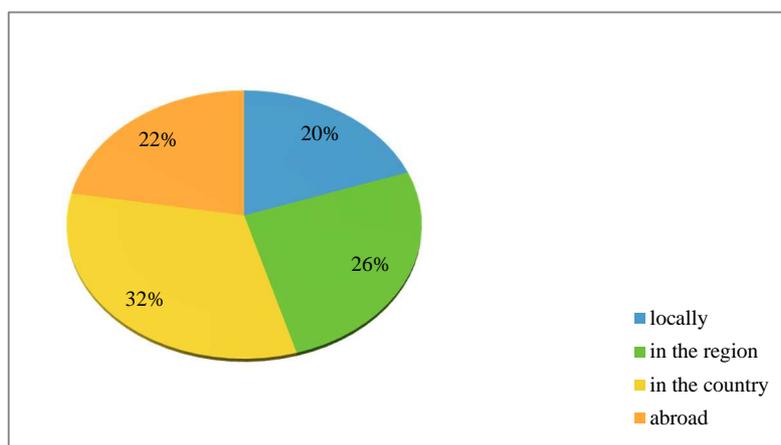


Fig. 1. Main customer of transport related industrial enterprises in Eastern Poland - by location

Rys. 1. Główny klient przedsiębiorstw przemysłowych w Polsce Wschodniej związanych z transportem - według lokalizacji

In the graph above showing the distribution of declared answers on the location of the main customer, enterprises which operate in Eastern Poland identified the target market as being located within the country (32%). The second target market is ranked as operating in the region (26%). The third target market is an international market (22%). The last target market where industrial companies offer their products are the customers which operate locally (20%). The fact that companies mainly sell their products within regional and national markets shows that domestic products are still not very competitive on the world market. This

may be a result of both product quality and price of the final product.

When it comes to the main supplier of transport-related industrial enterprises in Eastern Poland, in the group of 167 industrial enterprises in Eastern Poland 134 cooperated with suppliers on innovative projects. The graph illustrating the distribution of answers in terms of the main supplier for industrial enterprises which are cooperating on innovative projects is shown below.

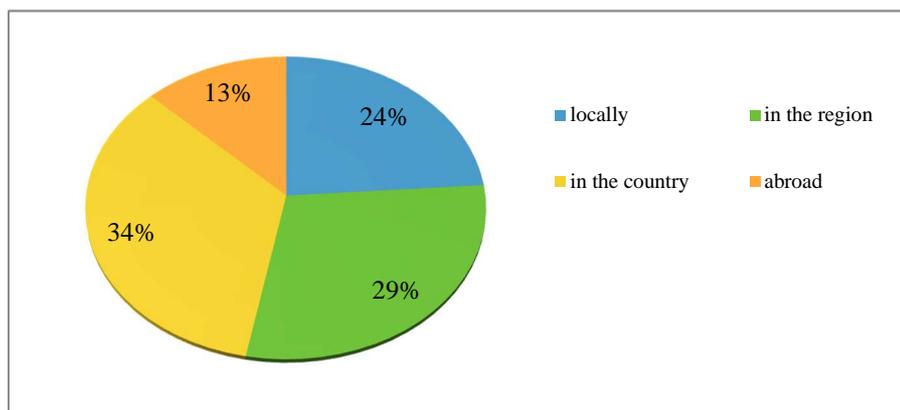


Fig. 2. Main supplier of transport related industrial enterprises in Eastern Poland - by location  
 Rys. 2. Głównym dostawcą przedsiębiorstw przemysłowych w Polsce Wschodniej związanych z transportem - według lokalizacji

As shown in the figure above, which presents the structure of declared answers on the location of the main supplier, it turned out that transport related industrial companies operating in Eastern Poland cooperate mainly with suppliers domestically (34%). The next main supplier selected was located locally (24%). The third position of suppliers located locally may be due to the fact that suppliers located so close are not able to offer the latest technology, which could allow the competition on broader markets than just the local one. The last group is suppliers located abroad (13%). This low number is not very surprising, since due to their since due to disproportionately low level of technology, Polish enterprises are still seeking competitive advance within country of

residence but don't have a high enough budget to finance projects with foreign partners.

### THE IMPACT OF RELATIONSHIPS WITH SUPPLIERS AND CUSTOMERS IN THE SUPPLY CHAIN ON INNOVATION ACTIVITY - PROBIT MODELING

The table below presents the results of probit modeling defining the impact of cooperation with customers on the innovation activity. Modeling was performed on a group of 112 enterprises declaring cooperation with customers in the area of new/improved products and processes.

Table 1. The value of the parameter with the independent variable "cooperation with customers" in probit models describing innovation activity in transport related industrial enterprises in Eastern Poland

Tabela 1. Wartość parametru przy zmiennej niezależnej "współpraca z klientami" w modelach probitowych opisujących działalność innowacyjną przedsiębiorstw przemysłowych w Polsce Wschodniej związanych z transportem

Innovation attribute	Parameter	Standard error	Statistics of t-student	p <sub>1</sub>	p <sub>2</sub>
Investments in R&D	+,813	0,147	3,924	0,82	0,43
Investments in machinery and technical equipment	+,589	0,301	2,273	0,56	0,30
Introduction of new products	+,602	0,309	2,342	0,79	0,51
Implementation of new technological processes (including):					
a) methods of manufacturing	+,478	0,179	2,023	0,69	0,42
b) production related systems	+,678	0,299	2,011	0,26	0,15
c) supporting systems	+,691	0,368	2,352	0,81	0,76

p<sub>1</sub> - the probability of occurrence in the study group  
 p<sub>2</sub> - the probability of occurrence in remaining group

The results of the research among transport-related industrial companies in Eastern Poland which cooperated with customers showed that opportunities for investing in R&D activity, in the case of cooperation with customers, was growing by as much as 90%. The likelihood of investment in machinery and technical equipment has increased by 87%. New products are introduced more frequently - almost by 55%, manufacturing processes by 64%, production-related systems by 73% and support systems (e.g. computer programs for accounting) not so much - 6.6%. It can be concluded that cooperation with customers has a positive effect on the implementation

of innovation processes in transport-related industrial enterprises in Eastern Europe, as evidenced by a positive sign in each of the parameters in the models statistically significant.

The table below presents the results of probit modeling defining the impact of cooperation with suppliers to the innovation activity attributes. Modeling was performed on a group of 134 enterprises declaring cooperation with customers in the area of new/improved products and processes.

Table 2. The value of the parameter with the independent variable "cooperation with suppliers" in probit models describing innovation activity in transport related industrial enterprises in Eastern Poland

Tabela 2. Wartość parametru ze zmiennej niezależnej "współpraca z dostawcami" w modelach probitowych opisujących działalność innowacyjną przedsiębiorstw przemysłowych w Polsce Wschodniej związanych z transportem.

Innovation attribute	Parameter	Standard error	Statistics of <i>t-student</i>	p <sub>1</sub>	p <sub>2</sub>
Investments in R&D	+,526	0,167	3,516	0,72	0,36
Investments in machinery and technical equipment	+,525	0,278	2,689	0,49	0,19
Introduction of new products	+,690	0,217	2,217	0,79	0,53
Implementation of new technological processes (including):					
a) methods of manufacturing	+,401	0,167	2,178	0,67	0,51
b) production related systems	+,679	0,367	2,128	0,42	0,29
c) supporting systems	+,409	0,270	2,166	0,83	0,67

p<sub>1</sub> - probability of occurrence in the study group  
 p<sub>2</sub> - probability of occurrence in remaining group

The results of research conducted among transport-related industrial enterprises in Eastern Poland which cooperated with suppliers has shown that opportunities for investing in R&D activity, in the case of cooperation with suppliers, increased by exactly 100%. The likelihood of investment in machinery and technical equipment increased by 158%. The probability of implementing new products increased by 49% and when it comes to the implementation of new or improved technological processes, such as manufacturing processes, the probability increased by 31%, production-related systems by and support systems by 45%.

The general conclusion is that cooperation with suppliers also has a positive effect on the innovation activity in transport-related industrial enterprises in Eastern Europe, as

evidenced by a positive sign at each of the parameters in the models which were statistically significant.

## CONCLUSIONS

Innovations in industrial systems are determined by the nature of relationships between enterprises and other units. This also includes cooperation with suppliers and customers, their location and the nature of the cooperation between them. Such factors affect the shape of industrial systems. Therefore, knowledge of the possible effects of cooperation in terms of innovation activity in the industry chain should be taken into consideration while developing innovation strategies in enterprises. The key to the development of the Eastern Poland region is

the implementation of innovations in enterprises, especially technological innovations in industrial enterprises.

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## ŁAŃCUCH DOSTAW I INNOWACYJNOŚĆ PRZEDSIĘBIORSTW SEKTORA TRANSPORTOWEGO W POLSCE WSCHODNIEJ

**STRESZCZENIE. Wstęp:** Jedną z strategii rozwoju wykorzystuje działalność B+R, jako główne źródło innowacji, która często realizowana jest we współpracy z innymi jednostkami, w szczególności jednak w łańcuchach dostaw, a zatem dotyczy współpracy przedsiębiorstw z ich odbiorcami i dostawcami.

Głównym celem pracy było określenie wpływu kooperacji o charakterze innowacyjnym na aktywność innowacyjną przedsiębiorstw przemysłowych sektora transportowego w Polsce Wschodniej.

**Metody:** Przeprowadzono badanie ankietowe dotyczącym wpływu powiązań z dostawcami i odbiorcami na innowacyjność przedsiębiorstw przemysłowych sektora transportowego w Polsce Wschodniej wśród 167 jednostek należących do tego sektora, funkcjonujących na obszarze Polski Wschodniej. W celu określenia oddziaływania wpływu powiązań z dostawcami i odbiorcami na aktywność innowacyjną przedsiębiorstw posłużono się modelami opartymi na analizie prawdopodobieństwa - modelami probitowymi.

**Wyniki:** Na podstawie przeprowadzonego badania można jednoznacznie stwierdzić, iż kooperacja przedsiębiorstw przemysłowych sektora transportowego z odbiorcami i dostawcami ma aktywizujący wpływ na wyszczególnione atrybuty innowacyjności przedsiębiorstw. Prawdopodobieństwo jednak waha się w zależności od przyjętej do badania zmiennej.

**Wnioski:** Kooperacja z dostawcami i odbiorcami jest istotna w kształtowaniu aktywności procesów innowacyjnych w przedsiębiorstwach przemysłowych sektora transportowego oraz ma charakter stymulujący na ponoszenie nakładów na działalność innowacyjną w różnych aspektach oraz implementację innowacyjnych rozwiązań z zakresu innowacji technologicznych (produktowych i procesowych).

**Słowa kluczowe:** logistyka, innowacyjność, łańcuch dostaw, przemysł, transport, region

## DIE LIEFERKETTE UND INNOVATION BEI TRANSPORT-UNTERNEHMEN IN OSTPOLEN

**ZUSAMMENFASSUNG. Einleitung:** Eine der heutzutage angewendeten Entwicklungsstrategien benutzt die Betätigung von B+R als die Hauptquelle von Innovationen, die in Zusammenarbeit mit anderen Wirtschaftseinheiten realisiert werden. Dies kommt jedoch besonders innerhalb von Lieferketten zustande, so betrifft diese Regel die Zusammenarbeit der Unternehmen mit ihren Empfängern und Lieferanten an. Das Hauptziel der Arbeit war es, den Einfluss einer innovativen Kooperation auf die innovativen Aktivitäten bei den im Transportbereich wirkenden und in Ostpolen befindlichen Industrieunternehmen zu bestimmen.

**Methoden:** Es wurde unter 167 in Ostpolen betätigten Unternehmen eine Umfrage hinsichtlich des Einflusses von Zusammenhängen zwischen den Lieferanten und Empfänger auf die Innovation der im Transportbereich wirkenden Industrieunternehmen durchgeführt. Zwecks der Bestimmung von Auswirkungen des Einflusses solcher Zusammenhänge zwischen den Lieferanten und Empfängern auf die innovative Aktivität der betreffenden Unternehmen hat man die auf Wahrscheinlichkeitsanalyse gestützten Modelle, d.h. die Probitmodelle in Anspruch genommen.

**Ergebnisse:** Aufgrund der durchgeführten Forschungen kann man eindeutig festlegen, dass die Kooperation der im Transportbereich tätigen Industrieunternehmen mit den Empfängern und Lieferanten einen aktivierenden Einfluss auf die ausgewählten Innovationsattribute der betreffenden Unternehmen ausüben kann. Die Wahrscheinlichkeitsquote oszilliert in Abhängigkeit von der für die Untersuchung in Anspruch genommenen Variable.

**Fazit:** Die Kooperation mit den einzelnen Lieferanten und Empfängern begünstigt wesentlich die Ausgestaltung von aktivierenden Innovationsprozessen in den im Transportbereich tätigen Industrieunternehmen und besitzt einen stimulierenden Charakter hinsichtlich der Erhöhung von Aufwendungen für die Förderung der Innovationsaktivität in unterschiedlichen Aspekten sowie für die Einführung konkreter Innovationslösungen im Bereich technologischer (produkt- und prozessgemäßer) Innovationen.

**Codewörter:** Logistik, Innovation, Lieferkette, Industrie, Transport, Region

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